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Generation the High Resolution DEM using ADS80 Aerial Push-Broom Camera

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Abstract**:** **Digital elevation model (DEM) is widely used as a basic source of point elevation data in many environmental fields. Because of high applicability and simple structure, it is playing a significant role in many studies. ADS80 Camera is considered one of the most usable, benefit tools for terrain data generation that can be used to create the (DEM). The aim of this present study is to validate a Digital elevation model (DEM) by created using stereo pairs of Airborne Digital Scanner (ADS80). The digital photogrammetric data obtained with10.000ft altitude flaying and 30cm GSD (ground sample distance) are evaluated through the relative vertical accuracy with regard to 30 points elevation obtained by Differential Global Positioning System (DGPS) throughout the tested area. G.P.S Leica Viva GNSS receiver is used to obtain these coordinates from entire study area areas for comparison with ADS80 imagery to get the accuracy of extracted (DEM). The RMSE, max, mean, min and Standard Deviation for the study are calculated from an area, about 1500 × 500 m^2 clos to Bader City, Egypt. The total RMSEz for elevation are found to be σΔz=±0.669m, STD=0.502m, mean=0.490m, max=1.644m, min=0.574m .According to standards of American Society for Photogrammetry and Remote Sensing (ASPRS)and the National Standard for Spatial Data Accuracy (NSSDA) the vertical accuracy for (DEM) extracting from ADS80 is reported at the 95% confidence level and it can produce contour map with contour interval of 2m and it can be categorized as Class VIII.**

Key Words: DEM, sensor, ADS80, Push-Broom.

INTRODUCTION

Specific data about the shape of the Earth's surface are in demanded for various missions like the obtained of orthoimages or flood modelling. The world countries, need information sources which are accurate, fast, and also can cover the whole area for monitoring purposes [1,4]. It be convinced that the map contouring is one of the important discovers in the mapping history, due to its appropriateness and obviousness to perceived value, the 3D topographical data. Digital discerptions of the terrain surface topography have always been a vital concentrated in geography and surveying studying.

DEM and gain the elevation information have been famous as one of the vital and basic elements to different data of geoscientific researches. The outlines of the major surface and subsurface internal structures to assess tectonic plate framework for Western South desert of Egypt, are using the DEM data through the images of Shuttle Radar Topographic Mission (SRTM). The up-to-date DEM can be created with the use various new technological advanced tools for geo-data acquisition such as space borne/ air borne, remote sensing (R.S) tools which has a capability to acquire the high-resolution continuous data collection even though in inaccessible terrain [2,3]. Various studies showed that the generation of DTM /DEM using the aerial camera is a crucial element to generate the high-accuracy of DEM. As though, there are few, researches conducted and mention that the worldwide for appearing the line scanning advanced technology like ADS80 for its use in creating high-resolution DEM for different types surface, the ADS80 sensor is the instrument has a capable of collecting the data continuously and over a wide, narrow area also including inaccessible terrain [5]. The goal of this studying is creating a DEM using ADS80 digital photogrammetric data with push-broom camera figure (1), respect of 30 cm (ground sample distance) GSD and assessment the relative vertical accuracy with consideration to 30 differential ground control points DGPS points gathered throughout the area of interested [2,6]

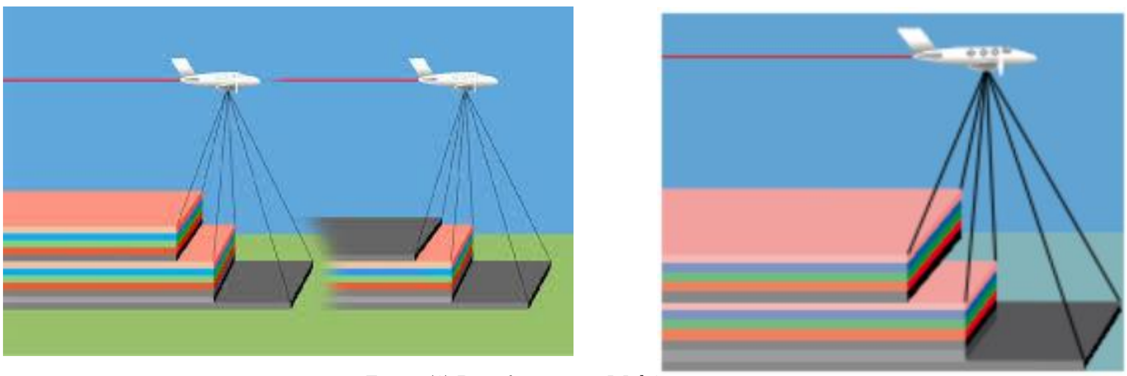

Figure (1) Data Acquisition With The Leica ADS80 Sensor [7]

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THE ADS80 CAMERA OVERVIEW:

The Leica ADS80 in combination with the new Leica XPro software is probably the best example of rapid productivity improvements in a production environment as a combination of hardware and dedicated software development [3]

*__Leica ADS-80 Imagery__ The push-broom scanner captures seamless images from various angles (permit for stereo viewing), creating separate images figure (1). The fact that every point is scanned three times, from three different viewing, also benefit in steady the image geometry, since push-broom scanned images have a poor geometry because each line represents an independent image The Leica ADS camera have, Spectral bands figure (2), (in nm) as follows: -

the Panchromatic Band from 465 to 676
the Red Band from 604 to 664
the Green Band from 533 to 587
the Blue Band from 420 to 492
the Near-infrared Band from 833 to 920

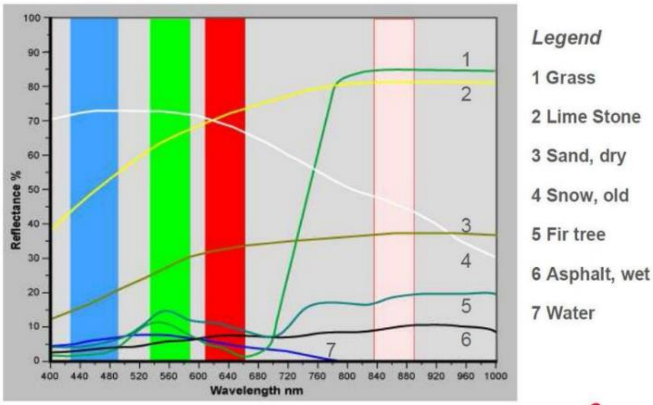

Figure (2) Narrow Spectral Band for Remote Sensing

*__Navigation System__ the global navigation satellite system GNSS supported navigation and graphical guidance is displayed during all stages of the operation survey flight.

* **The ADS80** Camera has an IMU (Inertial Measurement Unit) which it measures and informs on a plane's orientation, velocity and gravitational forces by the use of gyroscopes and accelerometers. Therefore, the velocity and Relative orientation from IMU unit, absolute position and the velocity from GPS are used for correcting the low-frequency errors in the navigation solution.

The Capability of ADS80 Camera There are several separate product levels created from the ADS-80 imagery: **Level 0**: raw imagery (usually not delivered to the client) because it contains considerable deformations and the total overlap between image strips is required in eliminate this distortion. **Level 1**: stereo image strips – corrected and georeferenced but not ortho-rectified it is derived from level 0 imagery and it was used for stereo-viewing, figure (3). **Level 2**: ortho-rectified imagery (can't be seen in stereo), It is derived from Level 1 imagery. And it is usually image tiles about (5 x 5 km). It is also used for acquiring earth surface features (building, lakes, roads, streams, etc.) into GIS layers. The Digital Elevation Model (DEM), points with surface elevations, was derived from Level 1 imagery through stereo images measurements.

Level 0

Level 1

Figure (3) Illustrated The Level 0 and Level 1

DATA COLLECTION AND GEOREFERENCING:

The images were accepted even faster processed at the velocity of flight. The Leica Geosystems' line sensor technology development is previously setting the standards in airborne data acquisition. Now-a- days the Leica's brand-new workflow solutions are setting the standards in digital image treatment, making the Leica ADS80 camera is the

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most powerful and most complete digital airborne imagery's solution. The improvement of the functionality, speeds up flight data treatment and saving the time and money the Fast quality control viewer for digital sensor imagery. Fastest image speed on the market, Radiometric corrections included in the image load chain and the multiple pulses in air (MPiA) technology were applied in figure (4).

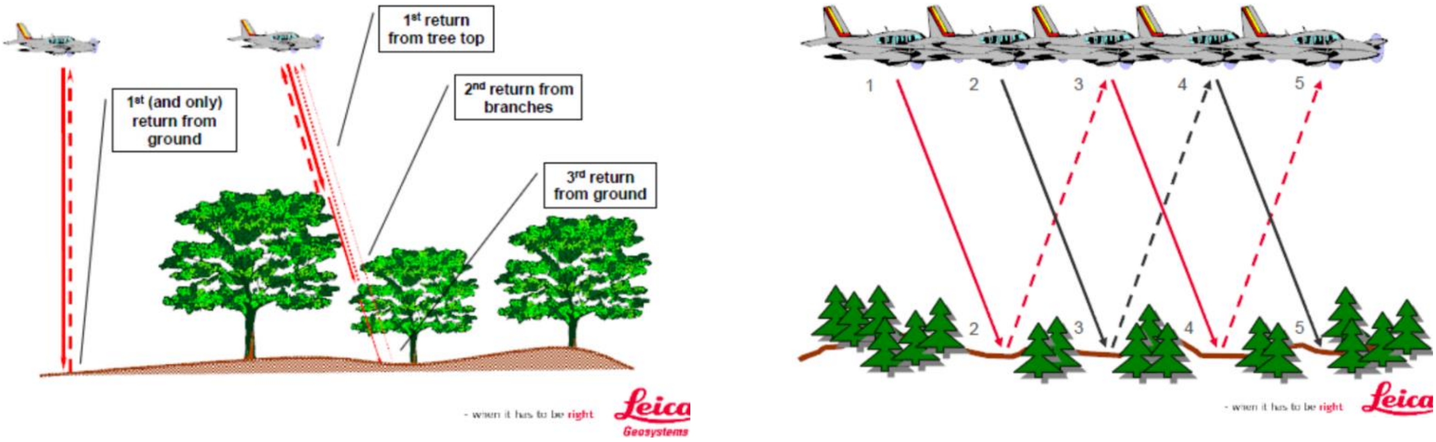

Figure (4) Illustrated The Multiple Pulses In Air (MPiA) Technology [8]

STUDY AREA:

In this research a selected an area lies at Bader City in east Cairo Egypt is located between 30° 07 5.8'' and 30° 06 20.28'' N latitudes and 31° 45 40 57.20''and 31° 45 42.8'' E longitudes, UTM Zone 36N. The area covers about 1500X500 m. The test area is characterized by nearly Hilly, average and plane leveled terrain as shown in figure (5).

Figure (5) Location of Study Area

METHODOLOGY:

The appropriate of planning flight should be performed Before starting the mission of aerial survey with consideration of the time for data captured, number of strips, flight line direction, and overlaps, they were created as required spatial resolution for topography surface. Then the DEM was generated through a block for the whole stripe by processing the Leica XPro 6.3 software. The 30 check points were observed and recognized into the image through ArcMape10.3 software. It could be accurately comparing the elevation of image data with the differential (DGPS) E, N, Z data at highly reliable common points. The differential GPS coordinates are measured with relative accuracy using stop-go method. ArcMape10.3and ERDAS Imagine 9.2 software's were used for image processing. Then RMSEs were calculated for both ADS80 images and check point in

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the field. The results were compared and evaluated in respect with both National Standard for Spatial Data Accuracy (NSSDA) and the (ASPRS).

FIELD WORK:

By using stop-go method to get the grid coordinates of thirty (C.Ps)well distributed on the studied area for the purpose of assessing the accuracy of the DEM producing from ADS80 images. Figure (6) illustrates the location of (C.Ps) These Check points which were collected in the field using Differential Global Positioning System (DGPS). measurement was observed by Leica Viva GNSS receiver. Leica Viva Global Navigation Satellite System (GNSS) is a multiple-frequency GNSS receiver, which is flexible, powerful, and reliable. It can produce all type of measurement data and generate Real Time Kinematic RTK, Differential Global Positioning System DGNSS, and National Marine Electronics Association NMEA outputs. A fixed station with known WGS84 coordinates, located on the study area was used as a reference station. The known coordinates of reference station according to WGS84 ellipsoid are:

Latitude = 30º 06’ 21.4” N
Longitude = 31º 45’ 41.7” E
Ellipsoidal Height = 238.51 m.

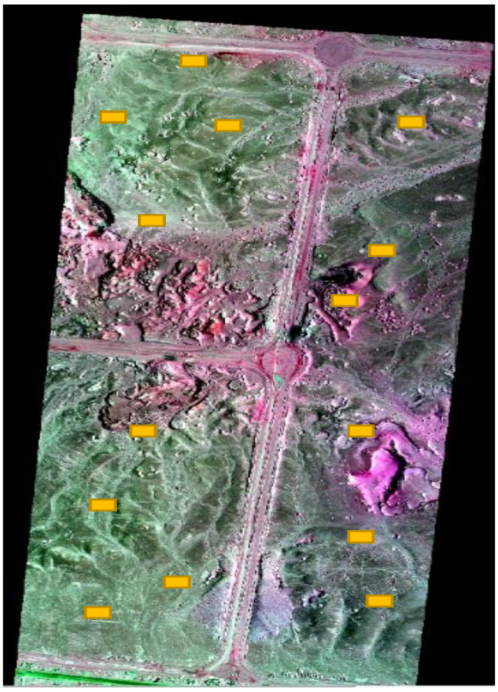

Figure 6 Map Showing Location of 30 DGPS Points Collected Covering The Entire Study Area

The reference station was settled by second Leica Viva GNSS receiver, during the data acquisition for the thirty (C.Ps). The maximum distance between the reference station and the selected, (C.Ps) was about 1300 m. The registered observations of the 30check point and reference station, were imported to Leica Geo Office software, to process the raw data. The processing parameters were, cut off angle of 15º, using broadcast ephemeris, troposphere model of Hopfield, and fix ambiguity up to10 km. table (1) shows the obtained coordinates of the 30check point, in coordinated and grid at UTM36 zone.

PRODUCINGDEMFROMADS80:

For generating a DEM from ADS80 digital photogrammetric it is configured to provide a stereo panchromatic data from three stereo angles, 16° backward, 2° nadir and 27° forward as the figure (1). But the largest angle (27° forward) combination, was kept away from for stereo photogrammetric purpose in order to reduce deformation. All the data acquisition in the study area had been done between 30-31° sun elevation angles on a flying altitude of 10,000 ft above mean sea level with north to south flight line. The swath width of the acquired ADS80 image strip is 3,500 m with GSD30cm, because the relative orientation from IMU unit. The absolute position and the velocity from GPS are used for correcting the low-frequency errors, all the producing images data are georeferenced [2]. As ADS80 aerial image data contain overlapping strips, the DEM was created through a block for all the strip using Leica XPro6.3software. figure (7) showing compatibility of the DEM with an image of the study area.

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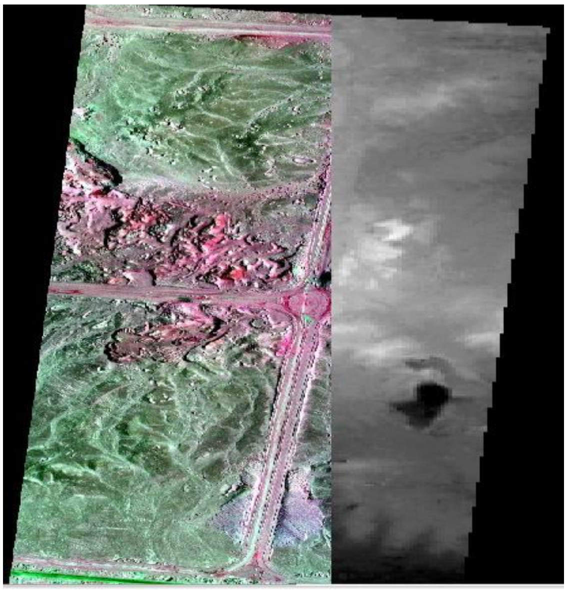

Figure (7) showing the DEM with and image of study area

ACCURACY ASSESSMENT:

The accuracy of DEM produced from ADS80 was evaluated by using the surveyed 30 check points (C.Ps), using the typical root mean square error (RMSE).To this end, the (C.Ps) were recognized in the DEM and orthoimages, through identified tool at ArcMap10.3 Software figure (7), and their coordinates were compared to the surveyed GNSS coordinates, resulting in RMSEz, the vertical accuracy were measures performed, table(1) shows coordinates comparison between those obtained from UTM_{36} GNSS and ADS80 image. it shows also the RMSEz, max, mean, min and Standard Deviation for the study area, which is about 1500 × 500 m^2.

Table [1] Comparison between ADS80 image UTM36 and GNSS Coordinates

U.T.M_{36} Grid Coordinates /m					
Point	Easting	Northing	Z field	Z image	Δz /m
1	380793.78	3332468.63	247.56	246.716	0.844
2	380899.87	3332459.49	246.59	246.034	0.556
3	380975.33	3332426.73	244.9	245.443	-0.543
4	381083.81	3332442.18	243.01	243.208	-0.198
5	381129.16	3332398.04	246.03	244.386	1.644
6	381200.59	3332362.66	242.94	242.07	0.87
7	380907.73	3332366.5	246.25	245.114	1.136
8	381112.61	3332238.62	241.93	241.601	0.329
9	380693.4	3331648.79	243.39	242.116	1.274
10	380760.62	3331585.73	243.13	242.886	0.244
11	381035.57	3331561.96	241.28	240.54	0.74
12	381030.2	3331501.22	240.53	239.615	0.915
13	380750.27	3331546.15	241.32	240.963	0.357
14	380761.04	3331466.06	239.67	239.548	0.122
15	380681.81	3331447.8	240.12	239.45	0.67
16	380683.57	3331368.3	237.54	237.839	-0.299
17	380665.23	3331329.94	236.81	236.645	0.165
18	380777.16	3331326.58	236.88	236.133	0.747
19	380826.7	3331326.06	238.02	237.379	0.641
20	381076.99	3331275.12	239.66	238.97	0.69
21	380773.12	3331446.68	239.48	238.977	0.503
22	380646.28	3331369.3	238.02	237.448	0.572
23	380723.75	3331346.31	237.14	237.714	-0.574
24	380826.56	3331304.92	236.69	236.104	0.586
25	381063.27	3331147.61	233.77	232.811	0.959
26	380813.5	3331152.48	235	235.035	-0.035
27	380763.91	3331169.6	235.35	234.607	0.743
28	380671.51	3331249.89	235.88	235.571	0.309
29	380632.99	3331250.05	235.76	235.353	0.407
30	380957.62	3331203.21	235.3	234.95	0.35
STD=0.502m	**mean=0.490**	**max=1.644**	**min=0.574**	**$RMSE_Z$=0.669** m	

COMPARISON OF DEM VERTICAL ACCURACY AND ADS80 IMAGE:

the This study aims to evaluate the vertical accuracy of digital surface model (DSM) derived from ADS80 image used in a project applied to studying area together with field ground surveying (C.P$_s$) observed, using differential (G.P.S). The results showed that **RMSE**$_Z$ = **±0.669**m, **min=0.574**m, **max=1.644**m, **mean=0.490**m, and **STD=0. 502m.Accordeaing** the vertical accuracy standards, table 2 showed the vertical accuracy criteria for the digital elevation information. this standard clarifies the vertical accuracy measurement separately from the contour interval. The suitable contour intervals are demonstrated by table (2).The users can obtained the contour intervals that could be produce different scale map from digital elevation data through the RMSEz amount which mentioned in table (2).In all cases demonstrated in table(2), the suitable contour interval is equal three times larger the RMSEz value, harmonic with the National Standard for Spatial Data Accuracy (NSSDA for Large-Scale Maps, compared National Map Accuracy Standard (NMAS) where the equivalent contour accuracy is 3.2 times the RMSEz value when considered that vertical errors follow up a normal distribution method[9]. Therefore, the vertical accuracy for ADS80 image reported at the 95% confidence level ranked as **class VIII**.

Table2 vertical Accuracy/Quality Examples for Digital Elevation Data [9]

Vertical Data Accuracy Class	RMSEz in Non - Vegetated Terrain (cm)	Non-Vegetated Vertical Accuracy (NVA) at 95% confidence Level (cm)	Vegetated Vertical Accuracy (VVA) at 95 Percentile (cm)	Appropriate Contour Interval Supported by the RMSEz Value	Recommended Minimum Nominal Pulse Density (pts/m2)/ Maximum Nominal Pulse Sopacing (meters)
I	1	2	2.9	3cm	>20/0.224
II	2.5	4.9	7.4	7.5cm	16/0.250
III	5	9.8	14.7	15 cm (~6")	8/0.354
IV	10	19.6	29.4	30 cm (~1)	2/0.707
V	12.5	24.5	36.8	37.5cm	1/1.000
VI	20	39.2	58.8	60 cm (~2)	0.5/1.414
VII	33.3	65.3	98	1- meter	0.25/2.000
VIII	66.7	130.7	196	2- meter	0.1/3.162
IX	100	196	294	3- meter	0.05/4.472
X	333.3	653.3	980	10- meter	0.01/10.000

CONCLUSION:

The DEMs can be produced at different spatial scales according to requirement of a particular application by adopting its own cost-effective technique, as a newly developed technique, ADS80 image with on a flying altitude of 10,000 ft above mean sea level with GSD30cm showed good results. The result of the accuracy evaluation with 30check points is **RMSE**$_Z$ = ±**0.669**m, **min=0.574m, max=1.644**m, **mean=0.490**m,and**STD=0.502m.**According by the vertical accuracy standers it can produce the contour map with contour interval 2m.According to standards of American Society for Photogrammetry and Remote Sensing (ASPRS)and the National Standard for Spatial Data Accuracy (NSSDA) the vertical accuracy of (DEM) extracted from ADS80 is reported as **class VIII.** There is some of advantages for using such system that can be mentioned as follows:

* Highest stability during data acquisition from the field while flying
* Equal resolution in all bands and there is No Pan-sharpening for using
* Requires 3 tie points only between lines (each 240km long of lines)
* The images that were produced from ASD80 are georeferencing because the camera has control unit contain **IMU** (Inertial Measurement Unit) and **GPS** are used for correcting the data.
* The ASD80 images has 4 bands (Red, Green, Blue and Near-infrared) therefore it can recognize and identifying the features which captured from field
* It can produce different map scales according to purpose requirements because it can control the flying altitude above mean sea level
* System Accommodated ASD80 sensors with a total weight from 5 kg up to 100 kg and No need for a mass compensator.
* Unlike the old images it's makes pollutions and it's not friendly with environment (hard copy images), but this one it is harmful effect with environment and users (digital images)

REFRENCE:

[1] Athar Abdu rahman Bayanudin1 and Retnadi Heru Jatmiko[2,3] (2016) (**Orthorectification of Sentinel-1 SAR (Synthetic Aperture Radar) Data in Some Parts of South-eastern Sulawesi Using Sentinel-1 Toolbox**) 2nd International Conference of Indonesian Society for Remote Sensing (ICOIRS) 2016
[2] Mritunjay, Kumar Singh & Snehmani & R. D. Gupta . (2015) (**High resolution DEM generation for complex snow covered**

Indian Himalayan Region using ADS80 aerial push-broom camera: a first time attempt) Arab J Geosci (2015) DOI 10.1007/s12517-014-1299-9

[3] RUEDI WAGNER& Heerbrugg (2011) **(Leica ADS80 and Leica XPro: A Total Solution for Photogrammetric Mapping) Wichmann/VDE Verlag, Belin & Offenbach, 2011**

[4] Tempelmann, U. & Downey, M. The "**Photogrammetric Load Chain" for ADS image data – an integral approach to image correction and rectification**. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B2.Beijing 2008

[5] Buehler, Y., Egli, L., Marty, M., & Ginzler, C. (2011): **Continuous, high resolution snow depth mapping using remote sensing techniques.** Presentation at the 6th EARSel/LISSIG workshop held in Bern, Switzerland, February 2011

[6] Beisl, U., Telaar, J. & von Schoenermark, M. (2008): **Atmospheric correction, reflectance calibration and BRDF correction for ADS40 image data.** The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B7. Beijing 2008.

[7] https://www.mdpi.com/1424-8220/12/5/6347/htm

[8] https://docplayer.net/docs-images/69/60730837/images/17-0.jpg

[9] American Society for Photogrammetry and Remote Sensing (ASPRS) Board approval in March 2014